USER'S MANUAL
IGOR XOP's FOR ITC-18 INTERFACE
VERSION 2.8

InstruTECH
Precision Instrumentation for Biological Research

20 Vanderventer Avenue, Suite 101E
Port Washington, New York 11050-3752 U. S. A.
Tel: (516) 883-1300 Fax: (516) 883-1558
Internet: sales@instrutech.com
support@instrutech.com
http://www.instrutech.com/

Table of Contents

Table of Contents 2

1 General Information 4
- 1.1 Product intended usage 4
- 1.2 Requirements 4
- 1.3 Files 4
- 1.4 ITC-18 Usage Overview 5
- 1.5 ITC-18 Hardware Overview 5

2 *ITC-18* XOPS for IGOR 8
- 2.1 Overview 8
- 2.2 Functions 8
  - ITC18Seq "DACstring", "ADCstring", Update mode: 8
  - ITC18Stim[wave]: 9
  - ITC18StimAppend[wave]: 9
  - ITC18StimClear[value]: 9
  - ITC18Samp[wave]: 9
  - ITC18SampAppend[wave]: 9
  - ITC18StartAcq[period], [flags], [external clock]: 10
  - ITC18StopAcq: 10
  - ITC18SetPeriod[period]: 10
  - ITC18SetDAC[DACchannel], [volts]: 10
  - ITC18SetADCRange[ADCchannel], [range]: 10
  - ITC18WriteDigital0[value]: 11
  - ITC18WriteDigital1[value]: 11
  - ITC18WriteAuxDigitalOut[value]: 11
  - ITC18SetDigitalInputMode[latch],[invert]: 11
  - ITC18SetExternalTriggerMode[transition],[invert]: 11
  - ITC18ReadAvailable[wave]: 11
  - ITC18WriteAvailable[wave]: 11

ITC18Reset: 11

ITC18StimAndSample[output wave, input wave, period, flags, clock mode]:.....12

3 Warranty Information.....13

3.1 Limited Warranty.....13

4 Other Products available from Instrutech Corporation.....14

1 General Information

1.1 Product intended usage

The Instrutech ITC-18 XOP is intended for research use only in a laboratory by persons trained in its use. Users are expected to have a working knowledge of WaveMetrics IGOR and the target operating system (MacOS or Windows).

The Instrutech ITC-18 XOP is not intended for medical use. The Instrutech ITC-18 XOP is not intended for use in life support situations, or in situations were improper operations or failure of the Instrutech ITC-18 XOP can result in personal injury.

Instrutech Corporation makes no representation that the design, implementation, or testing of the Instrutech ITC-18 XOP meet reasonable standards for use as a medical product.

As stated in the Instrutech Limited Warranty Statement, supplied with each product, "Instrutech Corporation expressly disclaims all warranties to buyer except the limited warranty set forth above, including without limitation to any and all implied warranties of merchantability and fitness for a particular purpose."

1.2 Requirements

The following items are required to use the Instrutech ITC-18 XOP*:*

1 ITC-18 Computer Interface

1 PCI-18, AT-18 or MAC-18 computer plug in card

1 IGOR pro 2.02 or higher

1.3 Files

The following files are included with the Instrutech ITC-18 XOP:

Macintosh specific files:

ITC18_68K_XOP_2.8	(68k XOP for MAC-18)
ITC18_PPC_XOP_2.8	(PPC XOP for MAC-18 and PCI-18)

Windows specific files:

ITC18 x86.xop

Common files:

ITC18 IGOR demo	(IGOR demo macro)
ITC18 Test	(IGOR demo macro)
ITC18XOP28.PDF	(this manual)

1.4 ITC-18 Usage Overview

The ITC-18 allows a computer to measure the response of a system to a stimulus. The computer creates a stimulus, which is output by the ITC-18. The ITC-18 samples the response. In the ITC-18, a single interval timer controls both inputs and outputs, which are updated synchronously. This allows programs using the ITC-18 too precisely determine the time relationship between stimulus and response.

The ITC-18 performs precise electrical measurements. Most data acquisition devices connect the measurement common to the computer digital ground. Switching noise from the computer couples through the data acquisition device to the system being measured. The ITC-18 uses optical isolation to separate the electrical system of the ITC-18 from that of the computer. This eliminates the effect of computer-generated electrical noise on the system being measured.

The ITC-18 allows the computer to perform real-time analysis and display during acquisition. Most data acquisition devices require frequent low-latency service from the host computer during acquisition. This precludes many other simultaneous operations. The ITC-18 has a large FIFO that is used to hold both the output stimulus and the acquired response. The ITC-18 can tolerate long latencies in service from the host computer.

1.5 ITC-18 Hardware Overview

The ITC-18 is an external data acquisition unit. The ITC-18 is connected to the host computer using an interface card. The interface card is designed for the bus used by the host computer. Interface cards are available for common bus systems such as ISA bus, PCI bus, and NuBus. The interface card is transparent to the user.

The ITC-18 is divided into a digital control side and an analog acquisition side. The two sides are connected over optical isolation, so there is no electrical connection between them. The ITC-18 contains a power supply independent of the host computer. This power supply is used only for the analog acquisition side. If the user turns off the power to the ITC-18, power is removed only from the analog side of the ITC-18. The digital control side of the ITC-18 will continue to operate as long as it receives power from the computer.

The ITC-18 contains a large FIFO memory with a capacity of 256K samples. To perform data acquisition, the host computer loads any initial outgoing stimulus into the FIFO. The computer then starts acquisition in the ITC-18. The ITC-18 reads the stimulus from the FIFO and replaces the stimulus with acquired data. The host computer can read the acquired data out of the FIFO. The computer can read from and write to the FIFO at any time, and read or write any amount of data. The ITC-18 does not enforce a block size for data transfers to the computer. The amount of data read or written is entirely at the convenience of the computer. For example, suppose the computer is sampling on 4 A/D channels at 10kHz each, for a total of 40kHz. A 256K sample FIFO will hold over 6400 milliseconds of data. The computer might check the FIFO for data approximately every 100ms to update a data display. Typically, the computer will find 4000 samples in the

FIFO. If the computer performs an operation that delays checking the FIFO for 250 milliseconds, the computer will find that 10,000 samples have accumulated during that time. It can then read part or all of the samples from the FIFO.

The ITC-18 contains a sequence memory that specifies the channels on which stimulation and acquisition takes place. The application sets this memory before data acquisition begins. During acquisition, the ITC-18 cycles through the sequence memory, writing data from the FIFO to the output channels specified in the sequence memory, and reading data into the FIFO from the input channels specified in the sequence memory. The ITC-18 samples channels in the order specified in the sequence memory. For example, the computer might load the sequence memory with two entries. The first specifies to write a sample to D/A channel 0 and to read a sample from A/D channel 3. The second specifies to write a sample to D/A channel 1, and to read a sample from digital inputs. During data acquisition, the ITC-18 will operate as follows: it will write a value from the FIFO to D/A channel 0 and replace it in the FIFO with a sample read from A/D channel 3. The ITC-18 will then write a value from the FIFO to D/A channel 1, replacing it with a sample from A/D channel 3. At each sampling interval the ITC-18 reads a sample from the FIFO and replaces it with a sampled value, under the control of the sequence memory. The ITC-18 always reads a value from the FIFO on each sampling interval, regardless of the setting of the sequence memory. Even if output is disabled, the ITC-18 reads and discards a FIFO value.

When the ITC-18 acquires a sample from the A/D converter, it does not immediately write that sample into the FIFO. Instead, the sample is transferred through several stages of a pipeline, until it is written. This means that when data acquisition begins, the first few samples written into the FIFO are the values that were in the pipeline when acquisition began, not the actual acquired data. When reading acquired data, the first three samples represent values from the pipeline, and should be discarded. The last three acquired data samples are never actually written into the FIFO.

When the ITC-18 writes a value from the FIFO to a D/A converter, the converter output does not update immedi1ately. The sample is actually written into a holding register in the D/A converter, and transferred to the output on the next converter update. Therefore, when starting acquisition, the output of each D/A converter will first be updated to the value in the holding register left by the previous acquisition. At the end of acquisition, the final output value to each D/A converter will not actually appear at the output. If the final value must appear, it should be repeated.

Analog input and output values are 16-bit signed integers. An integer value of zero specifies zero volts.

Each analog input channel has an A/D converter and an instrumentation amplifier. The computer can control the instrumentation amplifier, setting the input range of the A/D converter. The available analog input ranges are:

Range	Resolution
±10.24 V	312.5 μV
± 5.12 V	156.25 μV

± 2.048 V	62.50 μV
± 1.024 V	31.25 μV

The analog output range is always ±10.24 V. Digital inputs and outputs are grouped as 16-bit integers.

2 *ITC-18* XOPS for IGOR

2.1 Overview

An IGOR XOP is an extension to expand the abilities of the IGOR software. This XOP adds the ability to access the *ITC-18* Interface. It allows simple calls to the *ITC-18* computer interface, which can be accessed through IGOR macros. This will allow IGOR to import and export analog data through the ITC-18. Please refer to your IGOR documentation on using XOP's and writing macros.

2.2 Functions

Before the ITC-18 XOP's can be used the file ITC18_XOP_PPC_2.8, ITC18_XOP_68K_2.8, or ITC18 x86.xop must be copied into the "Igor Extensions folder". When Igor Pro is started, the XOP will be automatically loaded and ready for use.

Please note that the functions ITC18Open, ITC18Close, ITC18Rapid, and ITC18GetStatus are no longer supported. This XOP version will call ITC18Open when the XOP is initialized and ITC18Close when Igor is terminated. This approach eliminates memory allocation / de-allocation problems. ITC18GetStatus has been replaced with the commands ITC18ReadAvailable and ITC18WriteAvailable. This was done to eliminate differences between the XOP's and our standard device driver. The function ITC18Seq now has an additional parameter which allows output and input data to be simultaneously sampled. There have been a number of requests for using the ITC-18 and the IGOR XOP's to perform continuous acquisition. The new function ITC18StimAndSample has been added to handle these requests, see below for a complete description.

The functions are as follows:

ITC18Seq "DACstring", "ADCstring", Update mode:

Combines 2 strings into a sequence ram pattern and set the sequence to either update the input and output data with each sequence execution or to execute all simultaneously. For example ITC18Seq "0101","3245",0 will send the stimulus out of channels 0 and 1 and will read the samples from channels 3,2,4 & 5 in that order repeating every 4 ticks of the sample clock. If 1 was used instead of 0 for the Update mode parameter then the data will be preloaded to the output channel registers. When the last entry is executed all of the outputs and inputs will update simultaneously.

The TTL Digital output channels can be substituted into the sequence ram with the letters "D" and "T". "D" is used to select digital output channel 1 and "T" for digital output channel 0. The TTL Digital input channel can be substituted into the sequence ram with the letter "D". (Warning, samples from the Digital Input channel will be mixed into the sample buffer as a number from 0 to 32768 representing the binary pattern (same applies to the Digital Outputs). For a simple acquisition from one channel, use a command like ITC18Seq: "0","0",0.

ITC18Stim[wave]:

This will copy the contents of the wave into the stimulus buffer. It will translate the values from ±32768 into ±10.24 volts. The length of the wave will determine the length of the stimulus, maximum = 256 Kilosamples. Note: this command will reset the FIFO. Use ITC18StimAppend to add output data to the FIFO memory without resetting it.

ITC18StimAppend[wave]:

This does the same as ITC18Stim, but appends the wave onto the stimulus buffer already there. It does not load the stimulus at the beginning of the buffer. Be careful not to load beyond the 256 / (1024 optional) kilosamples limit of the stimulus buffer. Overloading will wrap around to the beginning of the buffer, and destroy your previously loaded values.

ITC18StimClear[value]:

The value is written to every location in the stimulus FIFO. "ITC18StimClear 0" is a good way to zero the stimulus buffer, and is faster than sending a large wave of zeros with the ITC18Stim command.

ITC18Samp[wave]:

This will read the sample buffer into the wave. The length of the wave determines how many samples are read. This command is to be used for retrieving data that is less than or equal to the FIFO length. This function will automatically make the adjustment for the pipeline.

ITC18SampAppend[wave]:

This command is used in conjunction with ITC18Samp when continuous acquisition is required. It will read the sample buffer into the wave. The length of the wave determines how many samples are read. For the best performance in continuous acquisition, the procedure should carefully track the number of input and output samples. The procedure should not allow the stimulus FIFO to become empty as well as extracting data from the FIFO before it becomes full. The procedure should also never extract all of the data samples in the FIFO otherwise acquisition will be halted. A procedure example is as follows:

Note that InWave and OutWave are 4000 point waves.

```
ITC18Stim OutWave              | 4000 output samples
ITC18StimAppend OutWave        | add an additional 4000 output samples
ITC18StartAcq 8,2,0            | 10 microsecond sampling
ITC18Samp InWave               | extract 4000 samples
do
  ITC18StimAppend OutWave      | add 4000 samples
  ITC18SampAppend InWave       | extract 4000 sample
```

```
while (1)                    | continue forever
ITC18StopAcq                 | terminate acquisition
```

ITC18StartAcq[period], [flags], [external clock]:

This command does four useful things: sets the sampling period (same as ITC18SetPeriod command), loads some flags for controlling data acquisition, sets the bit for the clock source, and starts the sampling clock. The flag fields are as follows:

0: Do not send any output, begin acquisition immediately. Will hold the D/A and digital output channels at there last setting.

1: Do not send any output, begin acquisition after the next external trigger. Will hold the D/A and digital output channels at there last setting.

2: Send output data, begin acquisition immediately.

3: Send output data, begin acquisition after the next external trigger.

The ITC-18 can be ordered with an optional external clock sync circuitry. When present and the external clock flag is set to 1 the ITC-18 sampling clock will be controlled by an external 12.8MHz clock source. When set to 0, the internal sampling clock will be used. This option allows multiple ITC-18's to acquire data synchronized to a single clock source. For most application, this bit should be set to 0. Note that if the external clock circuitry is not installed the internal clock will be used regardless of the bit setting.

For example: ITC18StartAcq 10,2,0 will start acquisition at 12.5 microsecond intervals as soon as the command is executed.

ITC18StopAcq:

This command will stop the sampling timer, which will terminate any ongoing acquisition.

ITC18SetPeriod[period]:

Sets the sampling period, must be > 5 and less than 82000 microseconds. ***Important note:*** the period parameter is in clock ticks and not in actual time. The ITC-18 runs on a 1.25 microsecond clock. The actual sampling clock setting is period *1.25 microseconds.

ITC18SetDAC[DACchannel], [volts]:

Forces the specified D/A channel (0..3) to a set voltage. Voltage range is between $\pm$10.24 volts.

ITC18SetADCRange[ADCchannel], [range]:

Each of the ITC-18 ADC channels can be programmed with an input range of +/- 1,2,5 or 10 volts. This command will set the specified range for the specified ADC channel. Valid parameter for this command is 0 to 7 for the ADC channels and 1,2,5 or 10 for range. Only the specified ADC channel will be changed. Default setting is for full scale ($\pm$10.24 Volts).

ITC18WriteDigital0[value]:

Set the 16 digital output lines for digital output channel 0. All 16 channels are updated simultaneously. For example to set all channels to high (TTL 5 volts) use a value of 32768. To set all to low, (TTL 0 volts) use a value of 0.

ITC18WriteDigital1[value]:

Set the 16 digital output lines for digital output channel 1. All 16 channels are updated simultaneously. For example to set all channels to high (TTL 5 volts) use a value of 32768. To set all to low (TTL 0 volts) use a value of 0. Note that this command will also control the 14 Current sink lines. These lines and connected in parallel with digital output channel 1.

ITC18WriteAuxDigitalOut[value]:

Set the 16 digital output lines for the internal AUX output port. All 16 channels are updated simultaneously. For example to set all channels to high (TTL 5 volts) use a value of 32768. To set all to low (TTL 0 volts) use a value of 0. Note that this port is located within the ITC-18 and is intended for OEM applications only.

ITC18SetDigitalInputMode[latch],[invert]:

Set the mode of the digital inputs. The latch value enables latching if set to 1, and disables latching if 0. If latching is enabled, inputs latch an asserted input that lasts more than 150ns. The invert value enables inversion of the inputs if it is 1, and disables inversion if 0.

ITC18SetExternalTriggerMode[transition],[invert]:

Control the behavior of the external trigger. If the transition value is 0, the ITC-18 triggers whenever the trigger input is high. If the transition value is 1, the ITC-18 triggers on a low-to-high transition of the trigger input. The invert value enables inversion of the trigger input if it is 1, and disables inversion if 0.

ITC18ReadAvailable[wave]:

Reads the number of samples available to read from the FIFO. Increments once per sampling clock tick while acquisition is running.

ITC18WriteAvailable[wave]:

Returns the number of samples available for writing to the FIFO. Increments once per sampling clock tick while acquisition is running.

ITC18Reset:

Performs a reset of the *ITC-18* by: loading the internal controller chips, setting the sample period to 10 microseconds, setting all four D/A channels to zero volts, clearing the digital outputs, setting the sequence ram to "0" & "0", and clearing the stimulus buffer. It can be used anytime to get the *ITC-18* back to a known state.

ITC18StimAndSample[output wave, input wave, period, flags, clock mode]:

This command is a general purpose acquisition function. It is especially useful for continuous acquisition. Any size output and input wave can be used. The function will take the size of the input wave and calculate the number of points to acquire. The output wave can be any size less than or equal to the input wave. When the output wave is less than the input wave then the last output value will remain on the DA or Digital TTL channels. The passed parameters are as follows:

output wave: any size wave with output data to be send out by the ITC-18.

input wave: any size wave that will receive the input data from the ITC-18.

period: sets the sampling period, must be > 5 and less than 82000 microseconds.

flags: sets the acquisition flags. Flags are as follows:

0: Do not send any output, begin acquisition immediately. Will hold the D/A and digital output channels at there last setting.

1: Do not send any output, begin acquisition after the next external trigger. Will hold the D/A and digital output channels at there last setting.

2: Send output data, begin acquisition immediately.

3: Send output data, begin acquisition after the next external trigger.

clock mode: The ITC-18 can be ordered with an optional external clock sync circuitry. When present and the external clock flag is set to 1 the ITC-18 sampling clock will be controlled by an external 12.8MHz clock source. When set to 0, the internal sampling clock will be used. This option allows multiple ITC-18's to acquire data synchronized to a single clock source. For most application, this bit should be set to 0. Note that if the external clock circuitry is not installed the internal clock will be used regardless of the bit setting.

A procedure example is as follows:

```
Macro LongSweep()
    Make /N=32000 outwave
    Make /N=64000 inwave
    outwave = sin (p/5000) * 1000
    ITC18SetSeq "0","0"
    ITC18StimAndSample outwave, inwave, 10, 2, 0
    Display inwave as "Analog Channel In"
EndMacro
```

3 Warranty Information

3.1 Limited Warranty

Instrutech Corporation warrants to the first purchaser, for a period of two years from the date of purchase, that this Instrutech Instrument (hereafter referred to as the "Product") will be free from defective workmanship and materials, and agrees that it will, at its option, either repair the defect or replace the defective Product or part thereof at no charge to the purchaser for parts and labor. The Product must be returned to Instrutech Corporation, postpaid and insured. Instrutech Corporation will return the Product, postpaid and insured, in the most appropriate method as determined by Instrutech Corporation. If a faster shipping service is desired by the customer, any additional special delivery expenses must be paid by the customer.

This warranty does not apply to shipping damage. Instrutech Corporation fully insures all shipments. Any claims of damage upon receipt must be filed with the carrier and Instrutech Corporation immediately.

This warranty does not apply to any exterior appearance item of the Product which has been damaged or defaced, which has been subjected to misuse and abuse, abnormal service or handling, or which has been altered or modified in design or construction.

This warranty does not apply to any interconnection cables supplied with the Product.

This warranty does not apply if any unauthorized repairs, modifications or alterations have been made to the Product.

This warranty applies to software products only to the extent of maintenance release software to correct improper operation of the Product. Software updates to increase the capabilities of the present product are not to be provided under the terms of this warranty. Updates will be sent at no cost to the customer by normal common carrier routes. If faster delivery is desired, the customer must assume any additional expenses for special delivery service.

No sales organizations, other than Instrutech Corporation itself, are authorized to make any warranties other than those described above, or to extend the duration of any warranties beyond the time period described above on the behalf of Instrutech Corporation. If Instrutech Corporation agrees to such a modification of this warranty, Instrutech will furnish a modified copy of this agreement, which must be presented if a claim is being made under these modified terms.

4 Other Products available from Instrutech Corporation

ITC-18 computer interface	True 16 bit interface with 4 D/A, 8 A/D, 32 digital output channels and 16 digital input channels. Available with interfaces for the ISA, PCI and NuBus computers.
ITC-16	4 D/A, 8 A/D, plus 16 digital I/O channels. Available with interfaces for the PC ISA Bus, Apple NuBus, and PCI Bus.
AT-18	Host Interface Card for the *ITC*-18 and ISA bus computers.
PCI-18	Host Interface Card for the *ITC*-18 and PCI bus computers.
VR-100B Digital Data Recorder	Eight channel VCR based digital data recorders.
VR-10B Digital Data Recorder	Two channel VCR based digital data recorder with built in programmable stimulator.
VR-111 Interface for VR10/100	IBM PC AT plug in card for direct digital transfer of data to the computer hard disk for video tape or in real time.
DVP-32/PCI interface	Digital video processing system for PCI bus. 40 Mhz 12 bit A/D with multistage processing pipeline and 32 bit DSP. Includes acquisition software.
EPC-9 Patch Clamp	Computerized patch clamp amplifier.
TAC	Single channel analysis for MacOS and Windows.
PULSE/PULSEFIT	Data acquisition, stimulator and analysis software for MacOS and Windows.
IGOR software	Graphing and data analysis for the MacOS, Windows95, and Windows NT .
ACQUIRE	Continuous acquisition software for MacOS, and Windows.

Call Instrutech Corporation at (516) 883-1300 for more detailed information, new products and prices. You may also check our WWW pages at http://www.instrutech.com/ for our latest product announcements.